On the time spent preparing grant proposals: an observational study of Australian researchers

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Title

On the time spent preparing grant proposals: an observational study of Australian researchers

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Contributors

AGB, PC and NG conceived and designed the study, and analysed the data. All authors interpreted the data, drafted the article or revised it critically for important intellectual content and approved the version to be published. AGB is the study chief investigator and acts as the guarantor.

Competing interests

DLH salary is supported from NHMRC funding.

AGB receives funding from NHMRC and QLD Government.

PC receives funding from NHMRC, NIH and several other national and international health funding agencies.

NG receives funding from NHMRC, ARC, NIHR, QLD Government, and is the academic director of the Australian Centre for Health Services Innovation.

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Abstract – word count: 272

Objective To estimate the time spent by researchers preparing grant proposals, and to examine whether spending more time increases the chance of success.

Design Observational study.

Setting The National Health and Medical Research Council (NHMRC) of Australia.

Participants Researchers who submitted one or more NHMRC Project Grant proposals in March 2012.

Main outcome measures Total researcher time spent preparing proposals; funding success as predicted by time spent.

Results The NHMRC received 3,727 proposals of which 3,570 were reviewed and 731 (21%) were funded. Among 285 participants who submitted 632 proposals, 21% were successful. Preparing a new proposal took an average of 38 working days of researcher time and a resubmitted proposal took 28 working days; an overall average of 34 days per proposal. An estimated 550 working years of researchers' time (95% confidence interval 513, 589) was spent preparing the 3,727 proposals, which translates into annual salary costs of AUD$66 million. More time spent preparing a proposal did not increase the chances of success for the lead researcher (prevalence ratio (PR) of success for 10 day increase = 0.91, 95% credible interval 0.78, 1.04) or other researchers (PR= 0.89, 95% CI 0.67, 1.17).

Conclusions Considerable time is spent preparing NHMRC Project Grant proposals. As success rates are historically 20–25%, much of this time has no immediate benefit to either the researcher or society and there are large opportunity costs in lost research output. The application process could be shortened so that only information relevant for peer review, not administration, is collected. This would have little impact on the quality of peer review and the time saved could be re-invested into research.

Article summary

Article focus

- Researchers would prefer to spend less time preparing grant proposals and more time on actual research.
- The time spent preparing grant proposals is thought to be large, but we do not have accurate estimates of the total time spent across Australia.

Key messages

- An estimated 550 working years of researchers' time was spent preparing proposals for Australia's major health and medical funding scheme.
- More time spent preparing a proposal did not increase the chances of success and there was no agreement between researchers' ranking of their proposals and the results from peer review.
- Most researchers understand that a perfect peer review system is not realistic.

Strengths and limitations of this study

- Our time estimates were retrospective, with no details on identifying the sections of the proposal that took the most time.
- We used a short survey to increase the response rate, but this means we have limited data on the participants and their institutions.
- Many researchers were reluctant to give us their proposal identification numbers, presumably because of confidentiality concerns.

INTRODUCTION

Project Grants are the major source of medical research funding in Australia, and were around 70% of all research funds awarded by the National Health and Medical Research Council (NHMRC) in 2012 [1]. While the amount of available funding has increased over time, the increase has not matched the growing number of proposals (there were 1,906 proposals in 2003 and 3,727 in 2012, a 96% increase). For Australian researchers, this increase in proposal numbers has led to declining success rates and budget cuts for successful proposals.

Project Grants aim to support single or small teams of researchers for a defined project from one to five years. The application process takes almost a year, and has remained essentially the same for the last decade. The funding round opens in December, full proposals are submitted online in March, assessed by two external reviewers (April–May), lead researchers provide responses to the reviewers' reports (May), grant review panels of 10–12 experts assess each proposal considering reports from two panel spokespersons and give each proposal a score (August–September). Funding is then allocated based on a ranking determined by the score until the budget is exhausted, and the successful proposals are announced (October-November). The budget for Project Grants beginning in 2013 was AUD $458 million.

The process Australia uses, involving the assessment of full proposals, is in contrast to several comparable funding bodies overseas which use staggered application processes. For example, the UK Wellcome Trust Investigator Awards first invite a research plan; shortlisted applicants are then invited to provide more information [2]. The UK Engineering and

Physical Sciences Research Council (EPSRC) have a similar staggered process for their Platform Grants [3], as do the USA National Science Foundation (NSF). The NSF's guidelines explain that a key reason for short-listing is to reduce the wasted effort of researchers spending time preparing proposals with a low chance of success [4].

Despite the importance of applying for research funding, the total time spent by researchers preparing and submitting proposals is not known [5]. Guidelines on how to effectively write grant proposals advise they cannot be written in a short amount of time [6], but we do not know if spending more time increases the chance of success. A Nobel Laureate in Physics, and Australian-based researcher, Professor Brian Schmidt recently highlighted the large amount of time Australian researchers were wasting on preparing lengthy proposals for Australian Research Council funding [7].

We surveyed the Australian medical research community in order to estimate their time spent preparing proposals and whether spending more time increased their chance of success. We also examined whether previous experience with peer review improved their success.

METHODS

Study design

In March 2012, Australian researchers working in health and medicine submitted 3,727 proposals to the NHMRC Project Grant funding scheme [8]. We attempted to contact the lead researchers of every proposal by contacting the offices of research of every Australian university and research institute. Of the 51 offices approached, 30 (59%) agreed to distribute

an e-mail invitation to their researchers. There was no reminder e-mail. Willing researchers completed a short online survey from March to May 2012. The funding outcomes were announced by the NHMRC in October 2012. This study was approved by the Queensland University of Technology Ethics Committee (approval number 1100001472).

Survey questions

The online survey asked researchers to consider their time spent on proposals submitted in March 2012. For each proposal we asked them if they were the lead researcher and how much time they spent (in days). We also asked them about their previous experience with the peer review system as a reviewer and expert panel member, which are roughly akin to being a peer reviewer for a journal and part of the editorial board. We asked for their salary in order to estimate the financial costs of preparing proposals. To protect the anonymity of our participants, and to minimise their time spent completing the survey, we did not ask them for extra personal details or for the name of their institution.

For researchers who submitted two or more proposals we asked them to rank their proposals in order of which most deserved funding. Researchers also responded to a hypothetical scenario concerning their desired level of reliability between two independent peer review panels (Box 1). This was used to estimate the desired reliability of the peer review process. The hypothetical numbers of 100 proposals and 20 funded were based on a realistic NHMRC Project Grant panel.

Box 1: Hypothetical scenario on peer review reliability

Question: Imagine that 100 Project Grant proposals in the same field have been reviewed by a panel of 10 experts. They selected 20 proposals for funding.

Now imagine that a second panel of 10 experts reviews the same 100 proposals and must independently decide on which 20 proposals deserve funding. How many of the 20 proposals originally selected for funding would you want to also be selected by the second panel?

Response options: Exactly the same 20 proposals, a difference of 1 proposal, [...], 20 completely different proposals.

Statistical methods

The total number of days spent preparing proposals was estimated using the following equation:

$$3727 \times \{(1 - P) \times [T(N,L) + (M - 1) \times T(N,O)] + P \times [T(R,L) + (M - 1) \times T(R,O)]\}$$

where 3,727 is the total number of proposals in 2012, P is the proportion of resubmitted proposals, T() is the average time spent in days for a combination of new or resubmitted (N or R) proposals, lead or other researchers (L or O), and M is the average number of researchers per proposal. This equation recognises that resubmitted proposals take less time than new proposals, and that lead researchers generally spend more time than the other researchers. This estimate on the scale of working days was scaled to working years by assuming 46 working weeks per year. A bootstrap 95% confidence interval was calculated by randomly re-sampling from the observed responses to capture the uncertainty in the time spent, number of researchers and proportion of resubmissions [9]. Of the 3,727 proposals

submitted, 18 were subsequently withdrawn [8]. These withdrawn proposals were included in our estimate of the total time, as this time is still valid for our aim of capturing the total researcher time spent preparing proposals across Australia.

We used logistic regression to estimate the prevalence ratio of success according to researcher experience and time spent on the proposal. Prevalence ratios are the ratio of two probabilities, whereas odds ratios are the ratio of two odds [10]. Using prevalence ratios allows us to make multiplicative statements about probabilities (e.g., twice as likely) that are not possible with odds ratios.

There were small amounts of missing data (0–7%) for the questions on researcher experience and times. These missing data were imputed using multiple imputation based on the observed responses. For example, 35% said they had previously served on a peer review panel, hence missing values to this question were randomly imputed as "Yes" with probability 0.35. The imputation and logistic regression model were performed simultaneously using a Bayesian model, hence the final estimates of the prevalence ratios for success incorporate the uncertainty due to missing data. The model was fitted using the Bayesian WinBUGS software [11] and the prevalence ratios are presented as means with 95% credible intervals (CIs).

We examined potential non-linear associations between time spent and success. These were: a threshold beyond which more time did not increase the probability of success, log-transformed time and a quadratic association; but found no statistically significant associations (results not shown). We compared the researchers' ranking of their proposals with their success or failure in the peer review system. For each pair of proposals from the same researcher we compared their relative low and high ranking with their funding success

(yes or no). We only examined those proposals where there was a difference in success, as pairs of grants that were both failures or both successes contain no information for this analysis. We examined these results using a two-by-two table, chi-squared test and Kappa agreement statistic.

RESULTS

Our online survey was started by 446 researchers, but only 285 (64%) provided us with their proposal number(s). We needed the proposal identification numbers in order to match the survey responses (completed from March to May 2012) with the success outcomes from the NHMRC (announced in October 2012). However, many researchers were reluctant to give us this information. The 285 who gave us their proposal numbers submitted 632 proposals. The funding success rate in our sample was 21%, the same as the overall NHMRC success rate (21%) which indicates that our sample was representative of the wider population. The NHMRC received 3,727 proposals of which 3,570 were reviewed, and 731 were funded, giving a success rate of 21% [8].

An estimated 550 working years of researchers' time was spent preparing the 3,727 proposals (95% confidence interval: 513, 589 working years). Based on the researchers' salaries, this is an estimated monetary cost of AUD$66 million per year, which is 14% of the NHMRC's total funding budget. Each new proposal took an average of 38 working days of researcher time, and resubmissions took an average of 28 working days; an overall average of 34 days per proposal.

More time spent on the proposal did not increase the probability of success (Table 1). Due to concern about a lack of power to detect an association between time spent and success, we used a retrospective power calculation. We had a 90% power to detect an increase in the probability of success of 0.028 for a 10 day increase in time spent (based on the observed times and successes of our sample). If we have missed a true association, it is likely to be smaller than a 0.028 increase in probability for 10 more days of time spent.

Experience with the peer review system, as either a reviewer or expert panel member, did increase the probability of success but these increases were not statistically significant (Table 1). Resubmitted proposals had a statistically significant lower probability of success compared with new proposals (prevalence ratio = 0.64, 95% CI: 0.43, 0.92).

There was no agreement between the researchers' rankings of their proposals and which ones were funded (Table 2). The chi-squared test showed no association ($X^2 = 0.93$, p-value = 0.34), and the Kappa agreement was negative (–0.06).

Researchers were willing to accept a wide range in reliability between two hypothetical peer review processes (Figure 1). The modal response was a difference of 5 proposals (meaning 15 the same), which is a 25% disagreement in funding between the two processes.

DISCUSSION

Australian researchers spend an enormous amount of time preparing grant proposals. We estimate that the 2012 NHMRC Project Grant scheme cost 550 working years of researchers' time, which is AUD$66 million in terms of estimated salary costs. To put this quantum of

resources into perspective, it exceeds the total annual staff costs at the Walter and Eliza Hall Institute (WEHI 2012, AUD$61.6 million), one of Australia's major medical institutes who produced 284 publications in 2012 [12].

As success rates for the Project Grant scheme are historically between 20% to 25%, the majority of time spent preparing proposals is wasted with no immediate benefit. Some wasted time will be salvaged by submitting failed proposals to other funding agencies or resubmitting next year. However, resubmissions took just 10 days less on average to prepare than new submissions, and resubmissions had a 36% lower probability of success (Table 1).

Spending more time on a proposal is no predictor of success (Table 1), and the poor agreement between researchers' rankings and funding success (Table 2) further demonstrate how hard it is to predict success and justify spending more time on proposals. These findings are consistent with previous studies on NHMRC Project Grants that have shown a high degree of variation in panel members' scores [13] and a low correlation between the scores assigned for track record and bibliometric measures [14].

Underestimating time and cost

Our cost estimates are likely to underestimate the true costs because some proposals are started but not submitted, and we did not capture the time of researchers who provided technical help or administrative staff who helped with the submission process. Also, our estimates do not include the costs of peer review, which would be the time of one to three external reviewers per proposal and an expert panel of 10–12 senior researchers meeting for a week, as well as the administrative time of organising this peer review.

Our findings are based on retrospective self-reported times spent preparing proposals, and we could not verify these times. Our study was designed to minimise participant burden and maximise our response rate by using a short survey that maintained anonymity. Participants completed our survey soon after the NHMRC closing date for submissions which should have reduced recall bias. At the time of completing the survey participants did not know if their proposal had succeeded, hence our results are not biased by disgruntled researchers inflating their times. Future research may use diaries to prospectively collect the time spent preparing proposals and identify the sections of the proposal that took the most time. We could also examine whether preparing a proposal that remains unfunded provides any longer term benefits to the researcher in terms of refining their scientific ideas.

Excessive information

Researchers would prefer to spend less time writing proposals and more time on actual research. Our results show that most researchers do not expect a perfect system (Figure 1). Hence the amount of information collected does not need to aim for the "ideal" system shown in Figure 2. Most researchers understand that a perfect system is unachievable. The hypothetical association between the information that the system collects (which determines the time spent by researchers) and the accuracy of the system is plotted in Figure 2. Underlying the figure is the notion that the marginal cost of providing more information is rising (which is consistent with our results regarding time spent on grant preparation and success) and the marginal benefit flowing from this information in improving the ranking of proposals is declining [15]. The standard way of optimising the amount of information collected is to equate the marginal benefits with the marginal costs – which occur at the

maximum net benefit. Importantly, beyond this point marginal costs to the applicant outweigh the benefits even though there may still be improvements in accuracy of ranking. One may also reach a point where the net benefits become negative, when additional information only confuses the ranking process.

Our results suggest that the current NHMRC Project Grant system collects more information than is necessary as the association between time spent (at an individual level) and success was negative (Table 1), putting it on the downward slope of Figure 2. Project Grant proposals are between 80 and 120 pages long, and panel members are expected to read and rank between 50 to 100 proposals. It is optimistic to expect accurate judgements in this sea of excessive information. An alternative application process is to use an initial short proposal with successful proposals being asked to provide more information that would then be used to determine funding.

Recommendations to minimise burden

Our time estimates are comparable with two small Australian studies on time spent preparing proposals for NHMRC Project Grants. In 2004 a sample of 69 researchers spent an average of 20 days per proposal [16]. In 2009 a sample of 42 lead researchers spent between 20 to 30 days per proposal, which, when extrapolated to the whole of Australia, gave an estimated total preparation costs of AUD$41 million [13]. In 2012, the Canadian Institutes of Health Research review of their Open Operating Grant Program included a survey of 378 researchers who spent on average 169 hours (or 23 7.5-hour working days) per proposal [17]. In Canada, new recommended reforms include an immediate reduction in the amount of information submitted to minimise burden on applicants and peer reviewers [17].

A recent review of health and medical research funding in Australia recommended that the NHMRC's online application process be simplified [18]. We agree, but also believe that the information requested for each proposal could be reduced. This is because the key scientific information used to judge a Project Grant's worthiness is just nine pages of a proposal that is between 80 to 120 pages. Therefore proposals could easily be shortened without any impact on peer review. The inclusion of a staged application process starting with an expression of interest (EOI), as used in the UK and USA, would further minimise the burden on researchers. If an EOI could be used to reject 30% of proposals, and assuming that an EOI takes one-quarter of the time to prepare as a full proposal, then (based on our survey) this would save 124 years of researcher time per year. This saved time is equivalent to funding 124 new post-doctoral positions per year.

Changes to eligibility rules for resubmitting proposals from previous funding rounds could reduce the total number of applications and improve success rates. In the UK proposals submitted to the EPSRC Platform Grant scheme (2009–2010 to 2011–2012) have almost halved (3379 versus 1938) and the success rate increased (30% versus 41%) after EPSRC implemented stricter eligibility rules including a Repeatedly Unsuccessful Applicants policy [3]. From our survey, the success rate for new proposals was higher than for resubmissions therefore limitations on the resubmission of Project Grants may reduce the time wasted preparing proposals by improving the chance of success.

The format of grant proposals could be shortened so that only information relevant for peer review, not administration, is collected. Further, the administrative data could be collected at a later date for only those proposals that were successful. Another option is to restructure the

format of proposals based on the total budget, where projects with smaller budgets can submit shorter proposals. The potential savings in researcher time are enormous as preparing research proposals takes between 1 to 3 months of the year. If more of this time could be dedicated to actual research then there would be more and faster medical research discoveries. Weighing down researchers in a lengthy grant proposal process is a poor use of valuable researcher time.

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Contributorship

AGB, PC and NG conceived and designed the study, and analysed the data. All authors interpreted the data, drafted the article or revised it critically for important intellectual content and approved the version to be published. AGB is the study chief investigator and acts as the guarantor.

Data Sharing

No additional data are available.

Competing Interests

DLH salary is supported from NHMRC funding.

AGB receives funding from NHMRC and QLD Government.

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Table 1 Prevalence ratios of funding success by researcher experience and time spent on proposal

Researcher's experience and time	PR	95% CI
Ever served on peer review panel (Yes vs No)	1.27	0.89, 1.74
Ever peer reviewed a proposal (Yes vs No)	1.33	0.78, 2.22
Salary (per $5000 increase)	0.99	0.94, 1.04
Resubmitted proposal (Yes vs No)	0.64	0.43, 0.92
Time for lead researchers (10 day increase)	0.91	0.78, 1.04
Time for other researchers (10 day increase)	0.89	0.67, 1.17

CI = credible interval

Table 2 Agreement between researchers' relative ranking of their proposals and funding success.

	Funding success	
Researcher's ranking	No	Yes
Low	82	92
High	92	82
Kappa agreement	–0.06	

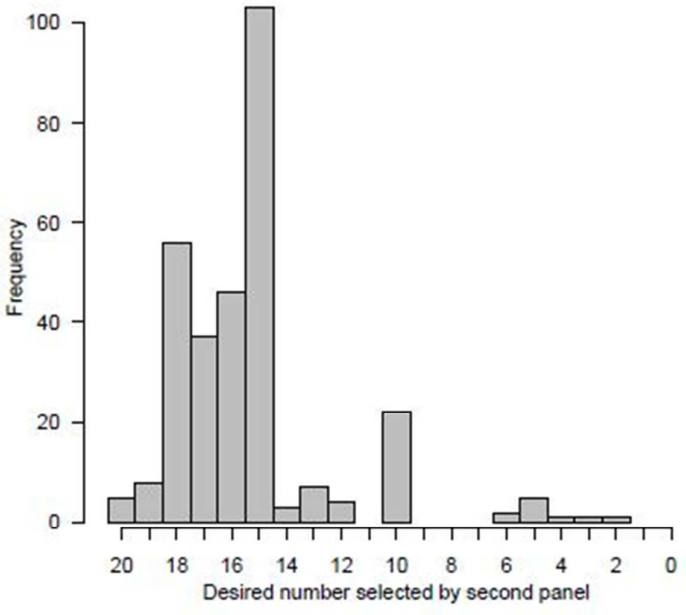

Figure 1: Desired reliability of a hypothetical system (see Box 1 for hypothetical question)

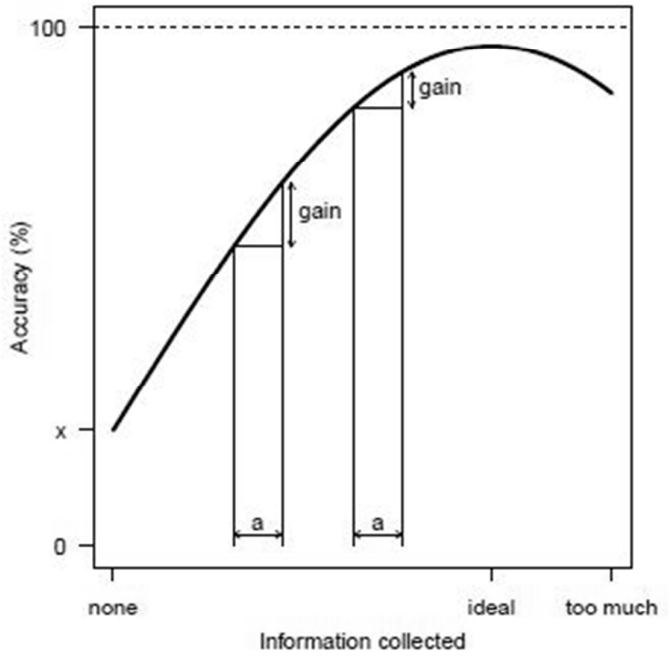

Figure 2: Hypothetical association between the information collected for peer review and the accuracy of awarding the best proposals. To draw this association we assume that all proposals can be ranked (without ties) from the best to the worst.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5,6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5,6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-9
		(*b*) Describe any methods used to examine subgroups and interactions	8,9
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7-9
		(*e*) Describe any sensitivity analyses	8,9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10, Tables 1-2, Figure 1
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8, Table 1
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10, Tables 1-2, Figure 1
Discussion			
Key results	18	Summarise key results with reference to study objectives	10,11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11,12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Conclusions Considerable time is spent preparing NHMRC Project Grant proposals. As success rates are historically 20–25%, much of this time has no immediate benefit to either the researcher or society, and there are large opportunity costs in lost research output. The application process could be shortened so that only information relevant for peer review, not administration, is collected. This would have little impact on the quality of peer review and the time saved could be re-invested into research.

Article summary

Article focus

- Researchers would prefer to spend less time preparing grant proposals and more time on actual research.
- The time spent preparing grant proposals is thought to be large, but we do not have accurate estimates of the total time spent across Australia.

Key messages

- An estimated 550 working years of researchers' time was spent preparing proposals for Australia's major health and medical funding scheme.
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- Most researchers understand that a perfect peer review system is not realistic.

Strengths and limitations of this study

- Our time estimates were retrospective, with no details on identifying the sections of the proposal that took the most time.
- We used a short survey to increase the response rate, but this means we have limited data on the participants and their institutions.
- Many researchers were reluctant to give us their proposal identification numbers, presumably because of confidentiality concerns.

INTRODUCTION

Project Grants are the major source of medical research funding in Australia, and were around 70% of all research funds awarded by the National Health and Medical Research Council (NHMRC) in 2012 [1]. Application numbers have steadily risen over time making the process more competitive; there were 1,881 proposals in 2003 and 3,727 in 2012, a 98% increase. For Australian researchers, this increase in proposal numbers has led to declining success rates and budget cuts for successful proposals.

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We surveyed the Australian medical research community in order to estimate their time spent preparing proposals and whether spending more time increased their chance of success. We also examined whether previous experience with peer review improved their success.

METHODS

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For researchers who submitted two or more proposals we asked them to rank their proposals in order of which most deserved funding. Researchers also responded to a hypothetical scenario concerning their desired level of reliability between two independent peer review panels (Box 1). This was used to estimate the desired reliability of the peer review process. The hypothetical numbers of 100 proposals and 20 funded were based on a realistic NHMRC Project Grant panel.

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Question: Imagine that 100 Project Grant proposals in the same field have been reviewed by a panel of 10 experts. They selected 20 proposals for funding.

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Response options: Exactly the same 20 proposals, a difference of 1 proposal, [...], 20 completely different proposals.

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The total number of days spent preparing proposals was estimated using the following equation:

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There were small amounts of missing data (0–7%) for the questions on researcher experience and times. These missing data were imputed using multiple imputation based on the observed responses. For example, 35% said they had previously served on a peer review panel, hence missing values to this question were randomly imputed as "Yes" with probability 0.35. The imputation and logistic regression model were performed simultaneously using a Bayesian model, hence the final estimates of the prevalence ratios for success incorporate the uncertainty due to missing data. The model was fitted using the Bayesian WinBUGS software [11] and the prevalence ratios are presented as means with 95% credible intervals (CIs).

We examined potential non-linear associations between time spent and success. These were: a threshold beyond which more time did not increase the probability of success, log-transformed time and a quadratic association; but found no statistically significant associations (results not shown).

We compared the researchers' ranking of their proposals with their success or failure in the peer review system. For each pair of proposals from the same researcher we compared their

relative low and high ranking with their funding success (yes or no). We only examined those proposals where there was a difference in success, as pairs of grants that were both failures or both successes contain no information for this analysis. We examined these results using a two-by-two table, chi-squared test and Kappa agreement statistic.

RESULTS

Our online survey was started by 446 researchers, but only 285 (64%) provided us with their proposal number(s). We needed the proposal numbers in order to match the survey responses (completed from March to May 2012) with the success outcomes from the NHMRC (announced in October 2012). However, many researchers were reluctant to give us this information. The 285 who gave us their proposal numbers submitted 632 proposals. The funding success rate in our sample was 21%, the same as the overall NHMRC success rate (21%) which indicates that our sample was representative of the wider population. The NHMRC received 3,727 proposals of which 3,570 were reviewed, and 731 were funded, giving a success rate of 21% [8].

An estimated 550 working years of researchers' time was spent preparing the 3,727 proposals (95% confidence interval: 513, 589 working years). Based on the researchers' salaries, this is an estimated monetary cost of AUD$66 million per year, which is 14% of the NHMRC's total funding budget. Each new proposal took an average of 38 working days of researcher time, and resubmissions took an average of 28 working days; an overall average of 34 days per proposal. Lead researchers spent an average of 27 and 21 workings days per new and resubmitted proposals, respectively, with the remaining time spent by other researchers.

More time spent on the proposal did not increase the probability of success (Table 1). Due to concern about a lack of power to detect an association between time spent and success, we used a retrospective power calculation. We had a 90% power to detect an increase in the probability of success of 0.028 for a 10 day increase in time spent (based on the observed times and successes of our sample). If we have missed a true association, it is likely to be smaller than a 0.028 increase in probability for 10 more days of time spent.

Experience with the peer review system, as either a reviewer or expert panel member, did increase the probability of success but these increases were not statistically significant (Table 1). Resubmitted proposals had a statistically significant lower probability of success compared with new proposals (prevalence ratio = 0.64, 95% CI: 0.43, 0.92).

There was no agreement between the researchers' rankings of their proposals and which ones were funded (Table 2). The chi-squared test showed no association ($X^2 = 0.93$, p-value = 0.34), and the Kappa agreement was negative (–0.06).

Researchers were willing to accept a wide range in reliability between two hypothetical peer review processes (Figure 1). The modal response was a difference of 5 proposals (meaning 15 the same), which is a 25% disagreement in funding between the two processes.

DISCUSSION

Australian researchers spend an enormous amount of time preparing grant proposals [12]. We estimate that the 2012 NHMRC Project Grant scheme cost 550 working years of researchers' time, which is AUD$66 million in terms of estimated salary costs. To put this quantum of resources into perspective, it exceeds the total annual staff costs at the Walter and Eliza Hall

Institute (WEHI 2012, AUD$61.6 million), one of Australia's major medical institutes who produced 284 peer-reviewed publications in 2012 [13].

As success rates for the Project Grant scheme are historically between 20% to 25%, the majority of time spent preparing proposals is wasted with no immediate benefit due to the failure to obtain funding. Some wasted time will be salvaged by submitting failed proposals to other funding agencies or resubmitting next year. However, resubmissions took just 10 days less on average to prepare than new submissions, and resubmissions had a 36% lower probability of success (Table 1).

Spending more time on a proposal is no predictor of success (Table 1), and the poor agreement between researchers' rankings and funding success (Table 2) further demonstrate how hard it is to predict success and justify spending more time on proposals. These findings are consistent with previous studies on NHMRC Project Grants that have shown a high degree of variation in panel members' scores [14] and a low correlation between the scores assigned for track record and bibliometric measures [15].

Underestimating time and cost

Our cost estimates are likely to underestimate the true costs because some proposals are started but not submitted, and we did not capture the time of researchers who provided technical help or administrative staff who helped with the submission process. Also, our estimates do not include the costs of peer review, which would be the time of one to three external reviewers per proposal and an expert panel of 10–12 senior researchers meeting for a week, as well as the administrative time of organising this peer review.

Our findings are based on retrospective self-reported times spent preparing proposals, and we could not verify these times. Our study was designed to minimise participant burden and maximise our response rate by using a short survey that maintained anonymity. Participants completed our survey soon after the NHMRC closing date for submissions which should have reduced recall bias. At the time of completing the survey participants did not know if their proposal had succeeded, hence our results are not biased by disgruntled researchers inflating their times. Future research could use diaries to prospectively collect the time spent preparing proposals and identify the sections of the proposal that took the most time. Future research could also examine whether preparing unsuccessful proposals provides any benefits to the researchers in terms of refining their scientific ideas.

Excessive information

Researchers would prefer to spend less time writing proposals and more time on actual research [16]. Our results show that most researchers do not expect a perfect system (Figure 1). Hence the amount of information collected does not need to aim for the "ideal" system shown in Figure 2. Most researchers understand that a perfect system is unachievable. The hypothetical association between the information that the system collects (which determines the time spent by researchers) and the accuracy of the system is plotted in Figure 2. Underlying the figure is the notion that the marginal cost of providing more information is rising (which is consistent with our results regarding time spent on grant preparation and success) and the marginal benefit flowing from this information in improving the ranking of proposals is declining [17]. The standard way of optimising the amount of information collected is to equate the marginal benefits with the marginal costs – which occur at the maximum net benefit. Beyond this point, marginal costs to the applicant outweigh the benefits even though there may still be improvements in accuracy of ranking. One may also

reach a point where the net benefits become negative, when additional information only confuses the ranking process.

Our results suggest that the current NHMRC Project Grant system collects more information than is necessary as the association between time spent (at an individual level) and success was negative (Table 1), putting it on the downward slope of Figure 2. Project Grant proposals are between 80 and 120 pages long, and panel members are expected to read and rank between 50 to 100 proposals. It is optimistic to expect accurate judgements in this sea of excessive information. An alternative application process is to use an initial short proposal with successful proposals being asked to provide more information that would then be used to determine funding.

Recommendations to minimise burden

Our time estimates are comparable with two small Australian studies on time spent preparing proposals for NHMRC Project Grants. In 2004 a sample of 69 researchers spent an average of 20 days per proposal [18]. In 2009 a sample of 42 lead researchers spent between 20 to 30 days per proposal, which, when extrapolated to the whole of Australia, gave an estimated total preparation costs of AUD$41 million [14]. In 2012, the Canadian Institutes of Health Research review of their Open Operating Grant Program included a survey of 378 researchers who spent on average 169 hours (or 23 7.5-hour working days) per proposal [19]. In Canada, new recommended reforms include a reduction in the amount of information submitted to minimise burden on applicants and peer reviewers [19].

A recent review of health and medical research funding in Australia recommended that the NHMRC's online application process be simplified [20]. We agree, but also believe that the

information requested for each proposal could be reduced. This is because the key scientific information used to judge a Project Grant's worthiness is just nine pages of a proposal that is between 80 to 120 pages. Therefore proposals could easily be shortened without any impact on peer review. The inclusion of a staged application process starting with an expression of interest (EOI), as used in the UK and USA, would further minimise the burden on researchers. If an EOI could be used to reject 30% of proposals, and assuming that an EOI takes one-quarter of the time to prepare as a full proposal, then (based on our survey) this would save 124 years of researcher time per year. This saved time is equivalent to funding 124 new post-doctoral positions per year.

Changes to eligibility rules for resubmitting proposals from previous funding rounds could reduce the total number of applications and improve success rates. In the UK proposals submitted to the EPSRC Platform Grant scheme (2009–2010 to 2011–2012) have almost halved (3379 versus 1938) and the success rate increased (30% versus 41%) after EPSRC implemented stricter eligibility rules including a Repeatedly Unsuccessful Applicants policy [3]. From our survey, the success rate for new proposals was higher than for resubmissions therefore limitations on the resubmission of Project Grants may reduce the time wasted preparing proposals by improving the chance of success.

The format of grant proposals could be shortened so that only information relevant for peer review, not administration, is collected. The administrative data could be collected at a later date for only those proposals that were successful. Another option is to restructure the format of proposals based on the total budget, where projects with smaller budgets can submit shorter proposals. The potential savings in researcher time are enormous as preparing research proposals takes between 1 to 3 months of the year. If more of this time could be

dedicated to actual research then there would be more and faster medical research discoveries. Weighing down researchers in a lengthy grant proposal process is a poor use of valuable researcher time.

ACKNOWLEDGEMENTS

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DATA SHARING

No additional data available.

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Table 1 Prevalence ratios of funding success by researcher experience and time spent on proposal

Researcher's experience and time	PR	95% CI
Ever served on peer review panel (Yes vs No)	1.27	0.89, 1.74
Ever peer reviewed a proposal (Yes vs No)	1.33	0.78, 2.22
Salary (per $5000 increase)	0.99	0.94, 1.04
Resubmitted proposal (Yes vs No)	0.64	0.43, 0.92
Time for lead researchers (10 day increase)	0.91	0.78, 1.04
Time for other researchers (10 day increase)	0.89	0.67, 1.17

PR = prevalence ratio, CI = credible interval

Table 2 Agreement between researchers' relative ranking of their proposals and funding success.

	Funding success	
Researcher's ranking	No	Yes
Low	82	92
High	92	82
Kappa agreement	–0.06	

Figure legends:

Figure 1: Desired reliability of a hypothetical system (see Box 1 for hypothetical question)

Figure 2: Hypothetical association between the information collected for peer review and the accuracy of awarding the best proposals. To draw this association we assume that all proposals can be ranked (without ties) from the best to the worst.

Title

On the time spent preparing grant proposals: an observational study of Australian researchers

Authors

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[2] University of Melbourne, Melbourne, Australia

Contributors

AGB, PC and NG conceived and designed the study, and analysed the data. All authors interpreted the data, drafted the article or revised it critically for important intellectual content and approved the version to be published. AGB is the study chief investigator and is the guarantor.

Competing interests

DLH salary is supported from NHMRC funding.

AGB receives funding from NHMRC and QLD Government.

PC receives funding from NHMRC, NIH and several other national and international health funding agencies.

NG receives funding from NHMRC, ARC, NIHR, QLD Government, and is the academic director of the Australian Centre for Health Services Innovation.

Word count: 3084

Abstract – word count: 274

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Design Observational study.

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Main outcome measures Total researcher time spent preparing proposals; funding success as predicted by time spent.

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We used logistic regression to estimate the prevalence ratio of success according to researcher experience and time spent on the proposal. Prevalence ratios are the ratio of two probabilities, whereas odds ratios are the ratio of two odds [10]. Using prevalence ratios allows us to make multiplicative statements about probabilities (e.g., twice as likely) that are not possible with odds ratios.

There were small amounts of missing data (0–7%) for the questions on researcher experience and times. These missing data were imputed using multiple imputation based on the observed responses. For example, 35% said they had previously served on a peer review panel, hence missing values to this question were randomly imputed as "Yes" with probability 0.35. The imputation and logistic regression model were performed simultaneously using a Bayesian model, hence the final estimates of the prevalence ratios for success incorporate the uncertainty due to missing data. The model was fitted using the Bayesian WinBUGS software [11] and the prevalence ratios are presented as means with 95% credible intervals (CIs).

We examined potential non-linear associations between time spent and success. These were: a threshold beyond which more time did not increase the probability of success, log-transformed time and a quadratic association; but found no statistically significant associations (results not shown).

We compared the researchers' ranking of their proposals with their success or failure in the peer review system. For each pair of proposals from the same researcher we compared their

relative low and high ranking with their funding success (yes or no). We only examined those proposals where there was a difference in success, as pairs of grants that were both failures or both successes contain no information for this analysis. We examined these results using a two-by-two table, chi-squared test and Kappa agreement statistic.

RESULTS

Our online survey was started by 446 researchers, but only 285 (64%) provided us with their proposal number(s). We needed the proposal numbers in order to match the survey responses (completed from March to May 2012) with the success outcomes from the NHMRC (announced in October 2012). However, many researchers were reluctant to give us this information. The 285 who gave us their proposal numbers submitted 632 proposals. The funding success rate in our sample was 21%, the same as the overall NHMRC success rate (21%) which indicates that our sample was representative of the wider population. The NHMRC received 3,727 proposals of which 3,570 were reviewed, and 731 were funded, giving a success rate of 21% [8].

An estimated 550 working years of researchers' time was spent preparing the 3,727 proposals (95% confidence interval: 513, 589 working years). Based on the researchers' salaries, this is an estimated monetary cost of AUD$66 million per year, which is 14% of the NHMRC's total funding budget. Each new proposal took an average of 38 working days of researcher time, and resubmissions took an average of 28 working days; an overall average of 34 days per proposal. Lead researchers spent an average of 27 and 21 workings days per new and resubmitted proposals, respectively, with the remaining time spent by other researchers.

More time spent on the proposal did not increase the probability of success (Table 1). Due to concern about a lack of power to detect an association between time spent and success, we used a retrospective power calculation. We had a 90% power to detect an increase in the probability of success of 0.028 for a 10 day increase in time spent (based on the observed times and successes of our sample). If we have missed a true association, it is likely to be smaller than a 0.028 increase in probability for 10 more days of time spent.

Experience with the peer review system, as either a reviewer or expert panel member, did increase the probability of success but these increases were not statistically significant (Table 1). Resubmitted proposals had a statistically significant lower probability of success compared with new proposals (prevalence ratio = 0.64, 95% CI: 0.43, 0.92).

There was no agreement between the researchers' rankings of their proposals and which ones were funded (Table 2). The chi-squared test showed no association ($X^2 = 0.93$, p-value = 0.34), and the Kappa agreement was negative (–0.06).

Researchers were willing to accept a wide range in reliability between two hypothetical peer review processes (Figure 1). The modal response was a difference of 5 proposals (meaning 15 the same), which is a 25% disagreement in funding between the two processes.

DISCUSSION

Australian researchers spend an enormous amount of time preparing grant proposals [12]. We estimate that the 2012 NHMRC Project Grant scheme cost 550 working years of researchers' time, which is AUD$66 million in terms of estimated salary costs. To put this quantum of resources into perspective, it exceeds the total annual staff costs at the Walter and Eliza Hall

Institute (WEHI 2012, AUD$61.6 million), one of Australia's major medical institutes who produced 284 peer-reviewed publications in 2012 [13].

As success rates for the Project Grant scheme are historically between 20% to 25%, the majority of time spent preparing proposals is wasted with no immediate benefit due to the failure to obtain funding. Some wasted time will be salvaged by submitting failed proposals to other funding agencies or resubmitting next year. However, resubmissions took just 10 days less on average to prepare than new submissions, and resubmissions had a 36% lower probability of success (Table 1).

Spending more time on a proposal is no predictor of success (Table 1), and the poor agreement between researchers' rankings and funding success (Table 2) further demonstrate how hard it is to predict success and justify spending more time on proposals. These findings are consistent with previous studies on NHMRC Project Grants that have shown a high degree of variation in panel members' scores [14] and a low correlation between the scores assigned for track record and bibliometric measures [15].

Underestimating time and cost

Our cost estimates are likely to underestimate the true costs because some proposals are started but not submitted, and we did not capture the time of researchers who provided technical help or administrative staff who helped with the submission process. Also, our estimates do not include the costs of peer review, which would be the time of one to three external reviewers per proposal and an expert panel of 10–12 senior researchers meeting for a week, as well as the administrative time of organising this peer review.

Our findings are based on retrospective self-reported times spent preparing proposals, and we could not verify these times. Our study was designed to minimise participant burden and maximise our response rate by using a short survey that maintained anonymity. Participants completed our survey soon after the NHMRC closing date for submissions which should have reduced recall bias. At the time of completing the survey participants did not know if their proposal had succeeded, hence our results are not biased by disgruntled researchers inflating their times. Future research could use diaries to prospectively collect the time spent preparing proposals and identify the sections of the proposal that took the most time. Future research could also examine whether preparing unsuccessful proposals provides any benefits to the researchers in terms of refining their scientific ideas.

Excessive information

Researchers would prefer to spend less time writing proposals and more time on actual research [16]. Our results show that most researchers do not expect a perfect system (Figure 1). Hence the amount of information collected does not need to aim for the "ideal" system shown in Figure 2. Most researchers understand that a perfect system is unachievable. The hypothetical association between the information that the system collects (which determines the time spent by researchers) and the accuracy of the system is plotted in Figure 2. Underlying the figure is the notion that the marginal cost of providing more information is rising (which is consistent with our results regarding time spent on grant preparation and success) and the marginal benefit flowing from this information in improving the ranking of proposals is declining [17]. The standard way of optimising the amount of information collected is to equate the marginal benefits with the marginal costs – which occur at the maximum net benefit. Beyond this point, marginal costs to the applicant outweigh the benefits even though there may still be improvements in accuracy of ranking. One may also

reach a point where the net benefits become negative, when additional information only confuses the ranking process.

Our results suggest that the current NHMRC Project Grant system collects more information than is necessary as the association between time spent (at an individual level) and success was negative (Table 1), putting it on the downward slope of Figure 2. Project Grant proposals are between 80 and 120 pages long, and panel members are expected to read and rank between 50 to 100 proposals. It is optimistic to expect accurate judgements in this sea of excessive information. An alternative application process is to use an initial short proposal with successful proposals being asked to provide more information that would then be used to determine funding.

Recommendations to minimise burden

Our time estimates are comparable with two small Australian studies on time spent preparing proposals for NHMRC Project Grants. In 2004 a sample of 69 researchers spent an average of 20 days per proposal [18]. In 2009 a sample of 42 lead researchers spent between 20 to 30 days per proposal, which, when extrapolated to the whole of Australia, gave an estimated total preparation costs of AUD$41 million [14]. In 2012, the Canadian Institutes of Health Research review of their Open Operating Grant Program included a survey of 378 researchers who spent on average 169 hours (or 23 7.5-hour working days) per proposal [19]. In Canada, new recommended reforms include a reduction in the amount of information submitted to minimise burden on applicants and peer reviewers [19].

A recent review of health and medical research funding in Australia recommended that the NHMRC's online application process be simplified [20]. We agree, but also believe that the

information requested for each proposal could be reduced. This is because the key scientific information used to judge a Project Grant's worthiness is just nine pages of a proposal that is between 80 to 120 pages. Therefore proposals could easily be shortened without any impact on peer review. The inclusion of a staged application process starting with an expression of interest (EOI), as used in the UK and USA, would further minimise the burden on researchers. If an EOI could be used to reject 30% of proposals, and assuming that an EOI takes one-quarter of the time to prepare as a full proposal, then (based on our survey) this would save 124 years of researcher time per year. This saved time is equivalent to funding 124 new post-doctoral positions per year.

Changes to eligibility rules for resubmitting proposals from previous funding rounds could reduce the total number of applications and improve success rates. In the UK proposals submitted to the EPSRC Platform Grant scheme (2009–2010 to 2011–2012) have almost halved (3379 versus 1938) and the success rate increased (30% versus 41%) after EPSRC implemented stricter eligibility rules including a Repeatedly Unsuccessful Applicants policy [3]. From our survey, the success rate for new proposals was higher than for resubmissions therefore limitations on the resubmission of Project Grants may reduce the time wasted preparing proposals by improving the chance of success.

The format of grant proposals could be shortened so that only information relevant for peer review, not administration, is collected. The administrative data could be collected at a later date for only those proposals that were successful. Another option is to restructure the format of proposals based on the total budget, where projects with smaller budgets can submit shorter proposals. The potential savings in researcher time are enormous as preparing research proposals takes between 1 to 3 months of the year. If more of this time could be

dedicated to actual research then there would be more and faster medical research discoveries. Weighing down researchers in a lengthy grant proposal process is a poor use of valuable researcher time.

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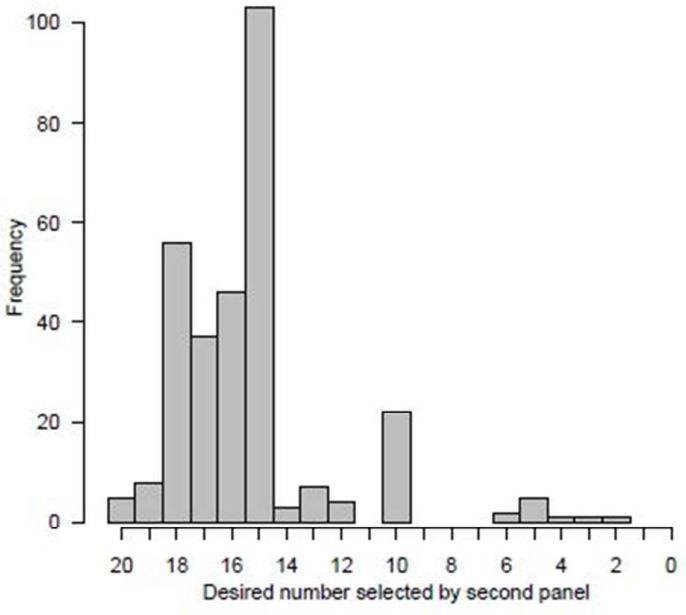
Table 1 Prevalence ratios of funding success by researcher experience and time spent on proposal

Researcher's experience and time	PR	95% CI
Ever served on peer review panel (Yes vs No)	1.27	0.89, 1.74
Ever peer reviewed a proposal (Yes vs No)	1.33	0.78, 2.22
Salary (per $5000 increase)	0.99	0.94, 1.04
Resubmitted proposal (Yes vs No)	0.64	0.43, 0.92
Time for lead researchers (10 day increase)	0.91	0.78, 1.04
Time for other researchers (10 day increase)	0.89	0.67, 1.17

PR = prevalence ratio, CI = credible interval

Table 2 Agreement between researchers' relative ranking of their proposals and funding success.

	Funding success	
Researcher's ranking	No	Yes
Low	82	92
High	92	82
Kappa agreement	–0.06	



406 Figure 1: Desired reliability of a hypothetical system (see Box 1 for hypothetical question)

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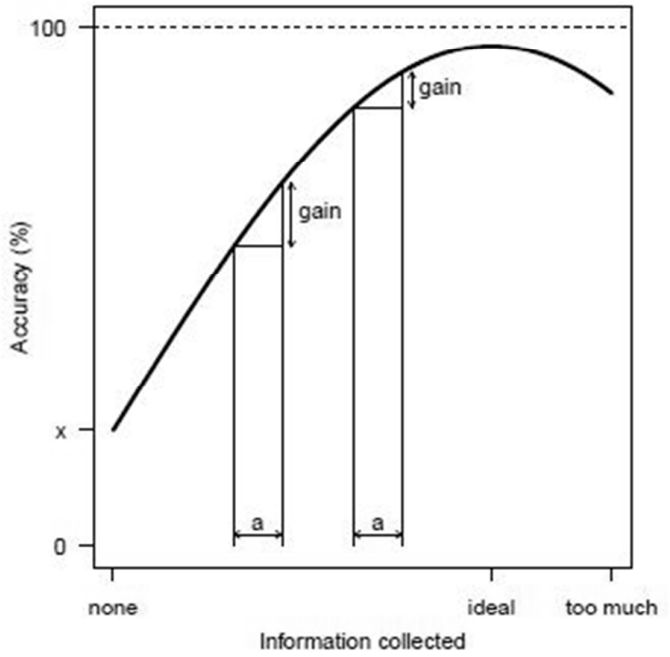

Figure 2: Hypothetical association between the information collected for peer review and the accuracy of awarding the best proposals. To draw this association we assume that all proposals can be ranked (without ties) from the best to the worst.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5,6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5,6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-9
		(*b*) Describe any methods used to examine subgroups and interactions	8,9
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7-9
		(*e*) Describe any sensitivity analyses	8,9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10, Tables 1-2, Figure 1
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8, Table 1
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10, Tables 1-2, Figure 1
Discussion			
Key results	18	Summarise key results with reference to study objectives	10,11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11,12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

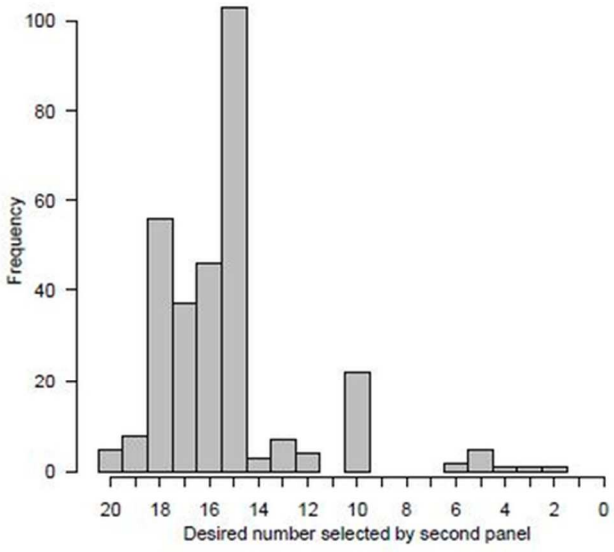

Figure 1: Desired reliability of a hypothetical system (see Box 1 for hypothetical question)

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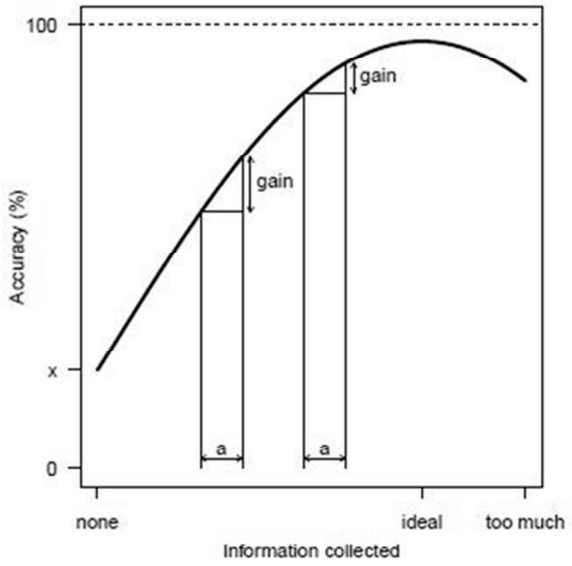

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